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Butt Fusion Integrity & Evaluation of NDE Technologies – Phase II

11th Quarterly Report (Eleventh Payable Milestone)

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Activities/Deliverable – Completed During Report Period:

Task #	Description	Schedule date	Complete date
1-52	Interactions to establish project boundaries, monitor analytical modeling and comprehensive testing, provide objective review of resulting data development, and establish consensus based recommendations.	03/31/09	03/31/09
3-48	Perform comprehensive long term sustained pressure testing and data analysis using the Rate Process Method and whole pipe creep rupture test	11/30/09	01/04/10
6-58	1st Quarterly Status Report	03/31/09	03/31/09

TECHNICAL STATUS

Joint Industry Steering Committee Interactions

During the past quarter, a review meeting was held with the NYSEARCH gas utility sponsors during April 2010 in Parsippany, NJ to review the final results of the Design of Experiments (DOE) analysis – discussed in the section to follow. Based on the consensus input of the NYSEARCH gas utility sponsors, Construct C was selected. This particular DOE model was considered to provide the more meaningful insight into the interactions of the key process variables. Specifically, the model incorporates key parameters including the heater iron temperature, interfacial pressure, ambient temperature, pipe size and grade into a single model.

In addition, there were continued discussions with the Plastics Pipe Institute (PPI) and regulatory staff relative to the technical next steps and outcome of the NYSEARCH gas utility sponsor meetings. The results of these discussions demonstrate that given the widespread use of PPI TR-33 and other industry standards, there may be a need to develop a stand-alone heat fusion joining specification specific for gas distribution application. This point will be revisited as the data from the comprehensive long term testing becomes available.

Development of an Analytical Model

During this quarter, a significant amount of time was spent on finalizing the overall DOE model to characterize the butt heat fusion process. The primary benefit of utilizing the DOE approach is that it allows one to simultaneously evaluate the individual and interactive effects of several process parameters which could affect the final desired response. As compared to a more heuristic approach, the DOE methodology helps to optimize and validate the overall process in a more controlled and cost effective manner.

As outlined in the previous quarterly report, a series of DOE models were developed for consideration by the respective stakeholders. Specifically, three separate models have been developed.

- Model A: Unique Experiments for Each Pipe Size
- Model B: Single Experiment with Range of Pipe Sizes from 2" – 8"
- Model C: Single Experiment with Range of Pipe Sizes between 2" – 8"

While each of the respective models had advantages and disadvantages, based on the consensus input from the steering committee guiding this program and input from various stakeholder group members, Model C was chosen as the best option. Specifically, the model specifies fabricating 36 specimens from both medium density and bimodal high density pipe ranging in sizes between 2" through 8" with an intermediate size of 4".

Given the possible interests in expanding the size to also include 12" pipe size, two separate analysis were performed. The first construct (Model D) was to expand the size requirements within Model C to also include 12" pipe size. While the overall number of specimens remained the same, the distribution of pipe sizes increased with two separate intermediate points (4" and 6"). Given the increased costs of performing the 12" whole pipe creep rupture tests, a separate hypothetical stand-alone model was developed to investigate the 12" pipe size – Model E. However, in the absence of long term test data, these efforts did not result in a final DOE model.

Based on the results of the modeling efforts to incorporate the 12" pipe size in the absence of actual empirical test data, it was resolved to further investigate the possibility of performing validation testing on 12" pipe size once the results of the Model C testing has been completed – budget permitting.

Comprehensive Long Term Testing

Having finalized the actual number of specimens and fusion process conditions, i.e. Model C, significant amount of time was expended in coordinating the pipe extrusion for the required pipe sizes. To date, all of the pipes in both grades of PE materials (MDPE and HDPE) have been developed and shipped to Southern California Gas Company for fabricating the necessary fusions.

In addition to securing the necessary pipe for joint fabrication and testing purposes, all of the administrative points have been finalized with the respective testing contractor (TWI, UK).

Finally, from the previous phase of this program, the long term sustained pressure testing specimens made using extreme heat fusion process conditions were removed from testing at 10,000 hours.

Integration with Standards and Specifications

There were continuing discussions with PPI to revise PPI TR-33 document to reflect some of the initial results of this program by increasing the heater iron temperature 500°F. While there is support to revise this document, additional data needs to be developed. It is hoped that the subsequent results of the testing from this phase of the program will help to support and validate this specific revision.

Moreover, there may be a need to develop a specific stand-alone ASTM specification for heat fusion joining for gas distribution applications. These discussions are in the early stages at this time.

Evaluation of NDE Technologies

During this quarter, significant amount of time was spent in coordinating the NDE testing. Specifically, several NDE equipment suppliers have agreed to inspect the final 36 fusion joints using their commercial (in some cases developmental) technologies to inspect the joints.

PROJECT SCHEDULE

The overall project schedule has not changed.

~~PAYABLE MILESTONES~~

~~Task #~~	~~Description~~	~~Schedule date~~	~~% Complete~~
~~1-52~~	~~Interactions to establish project boundaries, monitor analytical modeling and comprehensive testing, provide objective review of resulting data development, and establish consensus based recommendations.~~	~~03/31/09~~	~~100%~~
~~3-48~~	~~Perform comprehensive long term sustained pressure testing and data analysis using the Rate Process Method and whole pipe creep rupture test~~	~~11/30/09~~	~~100%~~
~~6-58~~	~~1st Quarterly Status Report~~	~~03/31/09~~	~~100%~~
~~2-53~~	~~Continued development of a design of experiments approach to characterize the two-way interactions of the butt heat~~	~~03/31/09~~	~~60%~~

	~~fusion process variables taking into account empirical data from testing 2-inch pipe specimens.~~		
~~3-54~~	~~Continued long term testing on 2-inch fusion specimens used to evaluate NDE technologies.~~	~~03/31/09~~	~~27%~~

RESULTS AND CONCLUSIONS

At this point, since the program is still in its nascent stages and the proposed whole pipe creep rupture testing has not yet been performed, there are no specific conclusions to present. However, there are two key points of emphasis.

Advancements in the Modeling Approach

there has been significant progress made with respect to finalizing the necessary test matrix on the basis of DOE statistical modeling. This represents a key advancement from the previous phase where the approach was a more heuristic approach intended to learn more about the overall process. Nevertheless, leveraging the results from the previous phase, appropriate ranges for the key process parameters were incorporated into the DOE statistical modeling.

A key point of emphasis is that the specific DOE model developed as part of this phase incorporates a non-dimensional factor for the heating time. In review of historical literature it was observed that pipe manufacturers provided heating times as guidance information based on the particular grade of resin. However, these times were considered to be independent of ambient temperature with vague guidance being provided to permit deviations based on environmental conditions. In review of the PPI TR-33 and ASTM F2620 documents, there is no guidance for the heating time. Instead, a visual approach is favored. In review of the ISO standards, a general factor is incorporated which is a factor of 10-12 times the wall thickness measured in millimeters. In addition, this factor is considered to implicitly incorporate the effects of environmental conditions. That is, regardless of the ambient conditions, the heating time shall always be 10-12 times the wall thickness.

Given that the heating time is integral to the integrity of the overall joint, this phase of the program incorporated a non-dimensional heating factor taking into account the various ranges of guidance which has been provided to the industry. As part of the model C construct, the range of heating time factor was chosen to in the range of 3-12 as specified in the various industry standards and guidance documentation. In doing so, the results will be useful in optimizing this key process parameters as function of both ambient temperature and pipe size since it is a multiplicative factor based on wall thickness.

Long Term Testing Approach

During the previous phase of this program, the consensus recommendation was to subject heat fusion joints made using extreme and nominal process conditions to the long term sustained pressure testing at elevated temperatures. The intent was to evaluate the efficacy of this particular test in providing useful information related to the continued long term performance of heat fusion joints.

The testing was allowed to continue up to 10,000 hours at various stress levels. To date, there were three failures of heat fusion joints made at extreme ambient temperature conditions. The lack of failures in the sustained pressure test is not evidence of the durability of even poorly made joints. Rather, they confirm fundamental principles that this test may not be a useful test in determining the overall strength of the heat fusion joints. Specifically, the long term sustained pressure test only imparts circumferential stresses. These are not the primary stresses which results in possible in-service failures. Instead axial stresses resulting from add-on stress or secondary stresses due to bending, thermal expansion/contraction are the primary stresses which need to be taken into account. The results of the testing and the lack of failures confirm the approach being utilized as part of this program and phase. Specifically, the results confirm the use of the whole pipe creep rupture test as a more meaningful test to discern the overall integrity of heat fusion joints and the effect of changes to process variables.

CHALLENGES

At this point, there are no challenges to the report. It is important to note, that given the uncertainty with respect to the actual failure times in the whole pipe creep rupture testing, it is difficult to project the possible impact to the overall schedule. As the samples are tested and the time to failures are being reported, more clarity in terms of the impact to the proposed schedule will be formed.

PLANS FOR THE FUTURE

Joint Industry Steering Committee Interactions

- During the 3Q 2010, there will be continued discussions among that various steering committee members towards establishing a consensus position with respect to technical approach.
- A steering committee meeting is being planned and will be held during 3Q 2010. The objective of this meeting will be to review all the technical aspects of this program and establish consensus with respect to changes to industry standards and specifications.

Development of an Analytical Model

- During 3Q 2010, no work is planned. As the whole pipe testing is initiated and the data becomes available, additional modeling may be necessary in the subsequent quarters.

Comprehensive Long Term Testing

- During 3Q 2010, all of the necessary joints will be fabricated and submitted to TWI (UK) where the whole pipe creep rupture testing will be initiated.

Integration with Standards and Specifications

- At this point, no work is planned in this area. Additional work may be required based on the input of the steering committee following the proposed meeting during 3Q 2010.

Evaluation of NDE Technologies

- During 3Q 2010, this will also be a key area of focus. It is proposed that all of the 36 specimens will be evaluated using various NDE techniques. At this point, 5 separate NDE suppliers have agreed to utilize their respective technologies to inspect the final fusion joints.